

The evaluation of two rotary instrumentation techniques under “operator-related variables” standardized conditions

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ABSTRACT

Objective: We aimed here to evaluate the enlargement characteristics of two nickel-titanium rotary instrument systems that use two different preparation techniques, in simulated root canals under “operator-related variables” standardized conditions. **Materials and Methods:** A total of 40 simulated canals in resin blocks were divided into two groups as the Mtwo group for use with a single-length technique and the ProTaper instrument system group for use with crown down technique. To standardize the operator-related variables, all preparations were carried out with a computer controlled device that was developed and used previously as described in a published study. The pre- and post-operative digital images of the canals were superimposed and measured at 11 levels from the apical tip. The distances between the pre- and post-operative outer lines of the root canals were measured at both the inner and outer sides of the curve. The amount of removed material and the symmetry of the preparations were evaluated. Statistical analyses were performed with Mann-Whitney test. **Results:** Significantly more material was removed by Mtwo at 9 levels and by ProTaper at 2 levels ($P < 0.05$) while no significant difference was determined at 11 levels. The preparations made with ProTaper were more symmetrical at 4 levels while no significant difference was determined at 7 levels. **Conclusion:** Mtwo removed significantly more material than ProTaper at different levels of the curved root canals. Mtwo and ProTaper made symmetrical preparations and maintained the original shape of the root canal at different levels under controlled operator-related variables.

Key words: Mtwo, preparation symmetry, ProTaper, resin blocks, rotary instrumentation

INTRODUCTION

One of the most important principles of shaping the root canal system is to maintain the original canal anatomy during a continuously tapering preparation. It is difficult to achieve this goal, especially in curved root canals because endodontic instruments are manufactured from straight metal blanks. This results in a tendency of the instrument to straighten itself inside the root canal. Thus, some areas in root canals tend to be over or under prepared.^[1]

Even if rotary nickel-titanium (Ni-Ti) instruments are able to maintain the canal shape in severely curved canals, the technique each rotary instrument uses can also affect the procedure. Today, most rotary instrument systems use the crown-down technique. The technique was introduced in 1984 for manual instrumentation, in which larger files precede smaller ones, which then in turn progress further apically.^[2] Lately, a new rotary instrument system, Mtwo (VDW; Munich, Germany) was introduced. With the evident design differences, the working

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method for the Mtwo, called single-length technique, was new for the rotary Ni-Ti systems. Actually, this was the "standardized technique," which used in-hand preparations as all instruments are taken to full working length (WL) from the beginning. This new instrument system and the technique were compared with the other Ni-Ti rotary systems in previous studies.^[3-11] However, to the best of our knowledge, the shaping ability of an instrument system using the single-length technique has not been compared previously with an instrument system using crown down technique under "operator-related variables" controlled conditions. In a previous study, we developed a computer-controlled device to control the operator-related variables and to test four different instrument systems under more standardized conditions.^[12]

The aim of this study was to evaluate the enlargement characteristics of two Ni-Ti rotary instrument systems and usage techniques: The Mtwo with a single-length technique and the ProTaper (Dentsply Maillefer, Switzerland) with crown down technique, in simulated root canals under standardized conditions of operator-related variables.

MATERIALS AND METHODS

Forty simulated canals in resin blocks (Dentsply Maillefer) were used; each canal was 12 mm in length with a 40° curve. One horizontal and one vertical groove were made on each block to achieve exact relocation in image superimpositions.

The pre- and post-operative images of the blocks were taken with a digital camera at 8 megapixel resolution and with a special appliance in which distance and angle between the camera and specimen were fixed.

The two basic motions in rotary canal preparations are rotary movement of the file and pecking motion. The first was controlled by using a handpiece with a torque- and speed-controlled electric motor VDW Silver (VDW, Munich, Germany) and the second motion, which achieves the short in-and-out movement of the file during canal preparation, was controlled and standardized by using a computer-controlled device and a previously designed program.

The device has five main parts: An electrical stepper motor, a holder and stabilizing arm, a handpiece, a screw bar and holder and the socket tray attached to the base.

The stepping motor was controlled by a specially written a computer program that works under

LabVIEW 5.0 software (National Instruments Corporation, Austin, TX, USA).

The specimen was fixed in the socket tray. The number of movements was then adjusted in the software and the operation was initiated. Linear vertical movement of the file was automatically stopped by the software. One pecking motion step of the device consisted of one short linear in (1 mm) and one short linear out (0.8 mm) movement of the file. The file tip progressed 0.2 mm in the canal per step movement.

When the movement of the file stopped, a rubber stopper was placed adjacent to the flat coronal surface of the resin block and fixed with light-curing resin. The file was removed and the distance between the fixed stopper and file tip was measured with a digital caliper to 0.01 mm accuracy. Simulated canals were continuously irrigated with 2.5% NaOCl during the instrumentation phase. After each instrument was removed, irrigation was repeated and a #10 stainless steel file (VDW; Antaeos, Munich, Germany) was placed until its tip reached the WL.

A total of 40 simulated canals were randomly divided into two groups, as the Mtwo group for use with a single-length technique and the ProTaper group for use with the crown down technique. The WL for all specimens was 12 mm. All sequences of the instrument series and master apical files (MAFs) used were according to the manufacturer's recommendations for use in severely curved canal preparations. MAF for Mtwo was #25/.06 and for ProTaper was an F2 file.

Pre- and post-operative images were superimposed by using the vertical and horizontal relocation grooves and the Corel-DRAW 9.0 software (Corel Corporation, Berkshire, UK). One pixel of the composite image represents 0.048 mm in real dimension. Distances between pre-operative and post-operative outer lines of the simulated canal were measured at 11 levels (0-10 mm) from the apical tip at the inner and outer sides of the curve on the superimposed images to 0.01 mm accuracy. The amount of removed material and the symmetry of the preparation were evaluated. Statistical analyses were performed with Mann-Whitney U-test.

RESULTS

All statistical results for the two instrument systems are presented in Figures 1 and 2.

For the inner curve, Mtwo removed significantly more material at 7 levels (4-10 mm) and the ProTaper

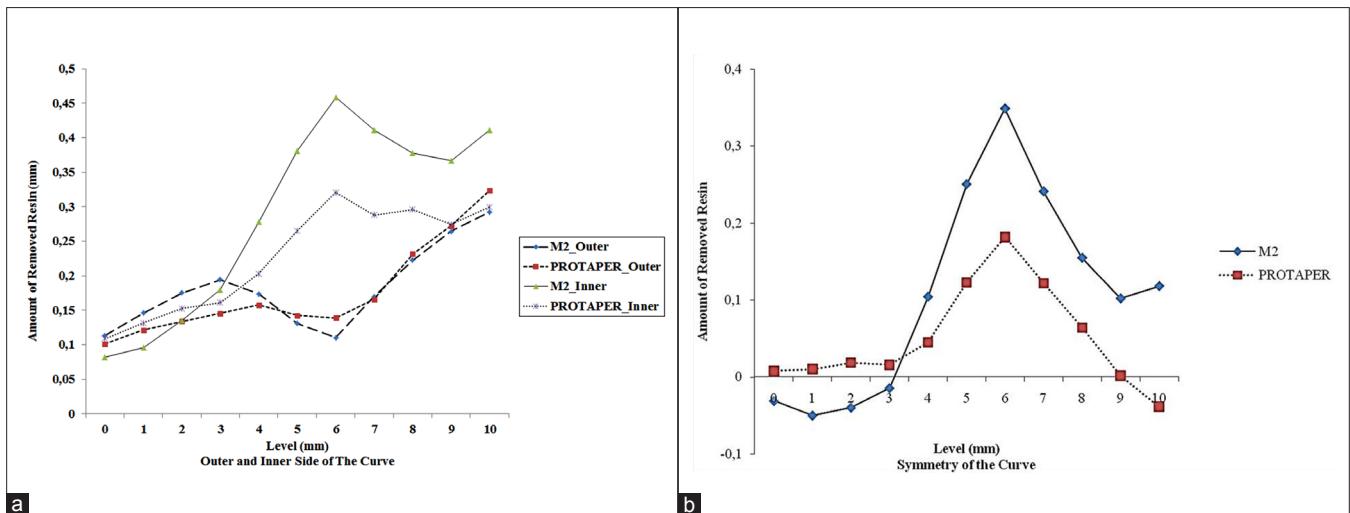


Figure 1: (a) Average thickness of canal wall removal by the two instrument systems measured at 11 levels ($P < 0.05$). (b) Symmetry of the preparations made by the two instrument systems measured at 11 levels ($P < 0.05$)

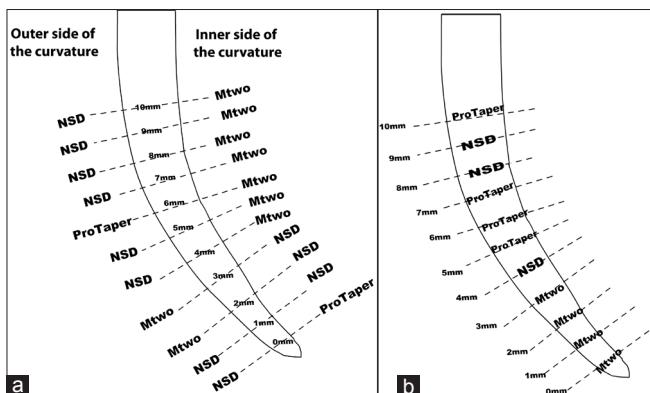


Figure 2: Illustrations of the statistically significant results. (a) Amount of removed resin for the both two systems at 11 levels and (b) For preparation symmetry on the 11 levels (no significant difference between instruments; $P < 0.05$)

at 1 level (0 mm) ($P < 0.05$). No significant difference between the systems was determined at 3 levels (1, 2, 3 mm).

For the outer curve, Mtwo removed significantly more material at 2 levels (2, 3 mm) and ProTaper at 1 level (6 mm) ($P < 0.05$). No significant difference between the systems was determined at 8 levels (0, 1, 4, 5, 7, 8, 9, 10 mm).

The preparations made with ProTaper were more symmetric at 4 levels (4, 5, 6, 7 mm, $P < 0.05$) and no significant difference was determined at 7 levels (0, 1, 2, 3, 8, 9, 10 mm).

DISCUSSION

The term operator-related variable involves all factors related with the operator, such as ability, experience

and proficiency. Those variables may affect the shape of a preparation and thus may also affect the results of the experiments. Thus, standardization of operator-related variables is a necessity to obtain more comparable results in experimental procedures.

In a previous study,^[12] we developed a computer-controlled device and by using this device and a torque- and speed-controlled electric motor, we tried to standardize the two main motions (rotary and pecking) in a rotary preparation process. In this study, we used the same device and computer program to control and adjust the following parameters in both instrument groups: Total distance of vertical file movement in the canal, number and frequency of pecking motions, distance of file tip progression and penetration depth of the instruments at each procedure step and vertical linear motion speed of the handpiece.

Nonetheless, the main limitations of the device are its unsuitability for simulated instrumentation of extracted teeth and its applicability only in artificial canal blocks. It also cannot reproduce human judgment relevant in the clinical situation.

The amount of removed material during instrumentation is an important parameter in strip perforations. In this study, we showed that Mtwo removed significantly more material than ProTaper at different levels of the curved root canals under controlled operator-related variables.

Plotino *et al.*^[13] compared the amount of dentine removed in the coronal portion of mesial roots of

mandibular molars prepared using ProTaper and Mtwo instruments and found that there was no difference between the ProTaper and Mtwo groups with respect to the amount of dentine removed. The results of that study were not similar to those of the present study.

Preparation symmetry is another important parameter in root canal preparations. Asymmetrical preparations may result in strip perforations or transportation of the canal, which affect the obturation procedures and thus possibly the success of the therapy. Kuzekanani *et al.*^[14] compared the shaping ability and cleaning effectiveness of the Mtwo and ProTaper systems in curved root canals in molar teeth and found that the Mtwo system gave a statistically smaller change in canal curvature and thus was better for maintaining the original shape of the root canal, with less transportation. The results of that study suggest that Mtwo instruments are preferable for situations where canals are curved, particularly for maxillary molars. Schäfer *et al.*^[4] compared the shaping ability of Mtwo instruments (using a single-length technique) with K3 and RaCe instruments (using a crown-down preparation technique) and found that canals prepared with Mtwo instruments remained better centered compared with those enlarged with K3 or RaCe instruments. Giovannone *et al.*^[15] compared the shaping ability of Mtwo and ProTaper instruments in simulated curved root canals in resin blocks and concluded that both instruments respected the original canal curvature, particularly in the areas at most risk of modification and they also showed good shaping ability in curved canals. Similar to the results of those previous studies, we found in this study that ProTaper made more symmetrical preparations in the middle portion and that no significant differences were determined in the remainder of the canal.

In most of the investigations made from radiographs or composite photographic image analyses like in the present study, investigators used mathematical formulations to determine the differences between pre-operative and post-operative outer lines; however, this type of investigation may not determine the exact amount of material removed or preparation symmetry results because those analyses are two-dimensional (Mesio-Distal) and there is also another dimension (buccolingual) in samples. Thus, experiments using three-dimensional analyses may give more accurate results in the root canal preparation investigations.

CONCLUSIONS

In the limits of the present study, Mtwo removed significantly more material than ProTaper at different levels of the curved root canals while both instruments made symmetrical preparations and maintained the original shape at different levels under conditions of more standardized operator-related variables.

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